

Devil's Slide Tunnels Project

New Austrian Tunneling Method (NATM)

The Devil's Slide Tunnels have been designed and constructed by applying the New Austrian Tunneling Method, or NATM.

This widely recognized tunneling method incorporates the strength of the surrounding rock during construction and uses two types of support: an initial lining of sprayed fiber-reinforced concrete (known as shotcrete), rockbolts, and lattice girders; and a final lining consisting of traditional reinforced concrete.

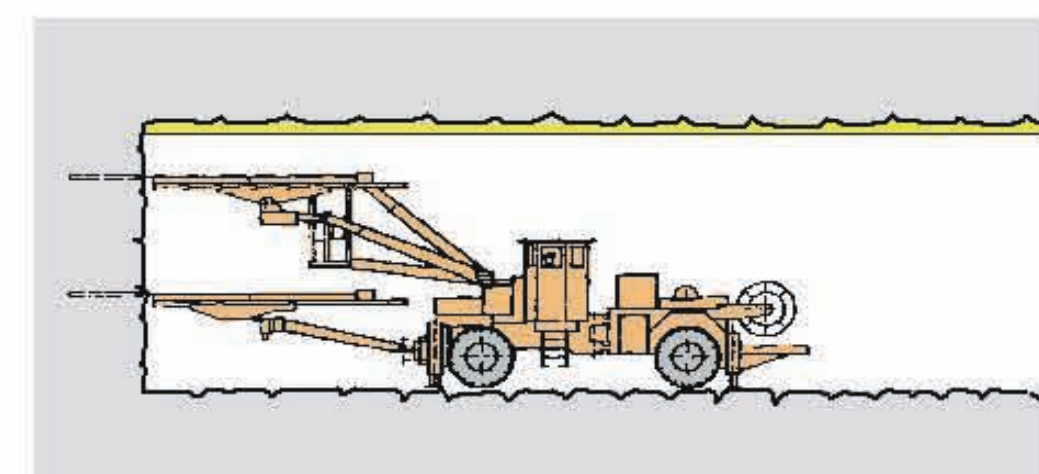
The initial lining is somewhat flexible and allows the rock to deform in a controlled fashion until an equilibrium is reached. By controlling the deformation of the rock using various initial lining elements, tunnel engineers can maximize the strength of the rock mass, while limiting the number of initial support elements.

Information or "Rock Data" was collected during the early stages of the design process by drilling several holes along the proposed alignment and collecting rock cores. Laboratory tests performed on the rock cores provided engineers with the data necessary to categorize various rock types to be encountered in the tunnel during construction. Along the Devil's Slide Tunnels, engineers determined that ten rock types would be encountered, and supporting these rock types would require five initial lining designs.

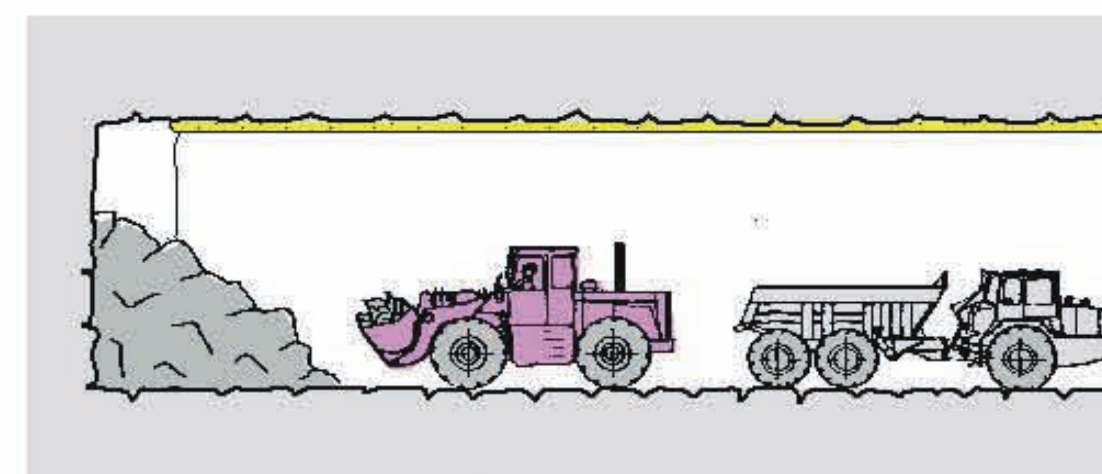
Engineers designed the excavation to occur in stages. The first section, or topheading, consists of roughly half the opening, followed by the other half, called the bench. Excavation methods include traditional equipment, highly specialized machinery designed specifically for the tunnel industry and blasting with controlled explosives. After excavation is complete, geologists identify the rock type and assess the behavior of the rock mass immediately after excavation.

Initial support elements are then installed based on the initial lining design for the encountered rock type. Survey points are installed periodically throughout the tunnel to monitor deformation of the initial lining. The final step is the construction of the final lining and the roadway.

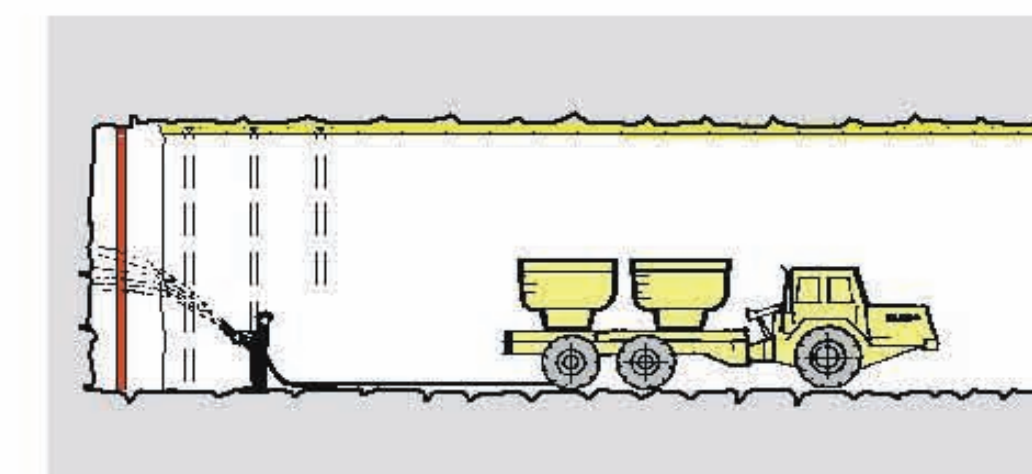
The flexibility of the New Austrian Tunneling Method (NATM) allows engineers to adjust reinforcing elements based on observed rock behavior. These principles provide for a tunnel to be constructed at a reasonable cost without sacrificing safety to the workers or the traveling public.



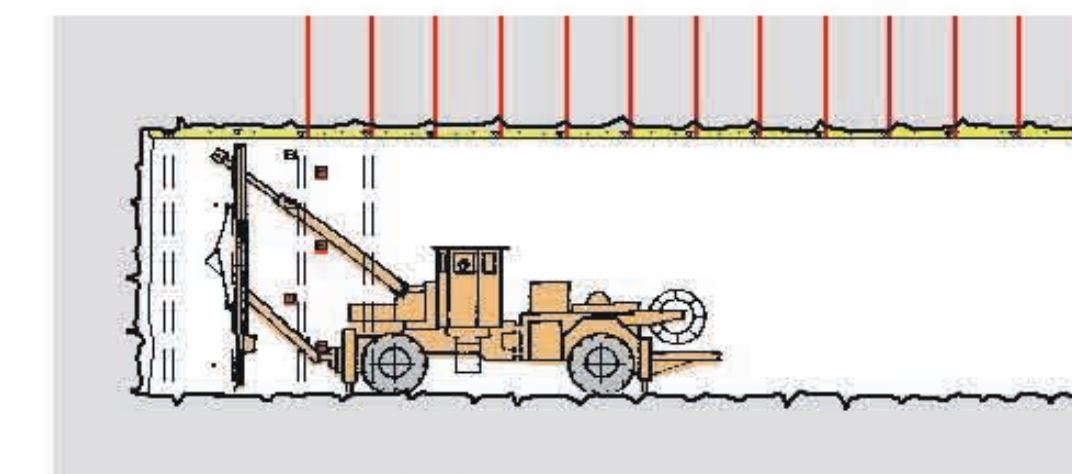
Excavating



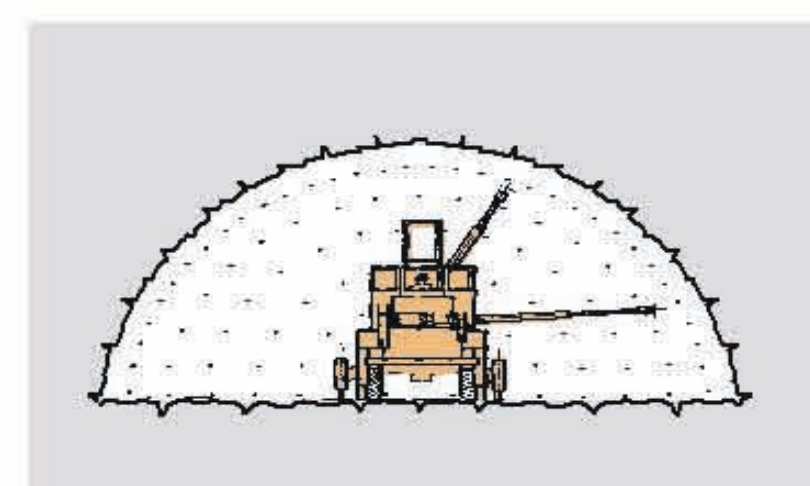
Mucking



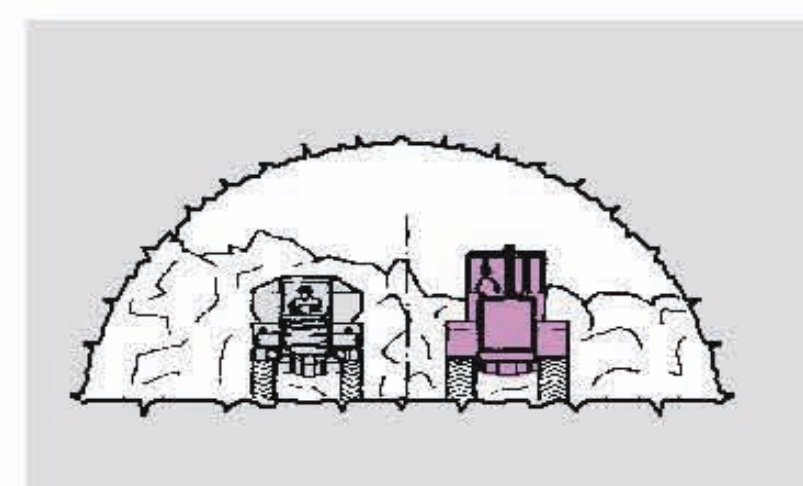
Installing Lattice Girders



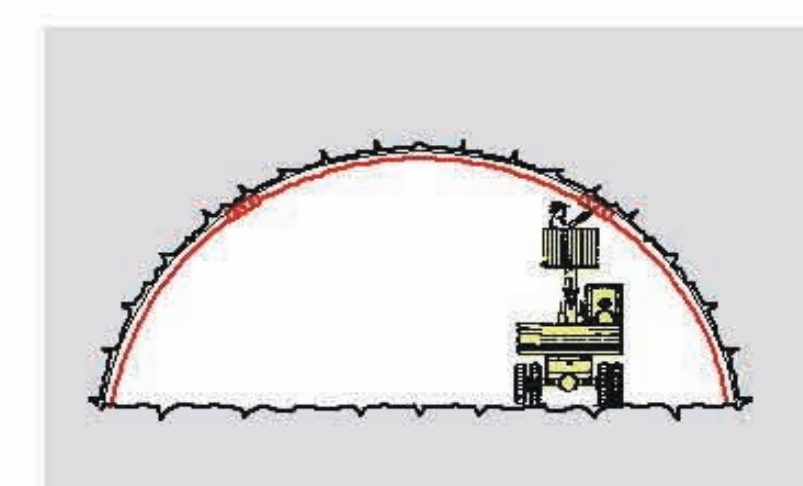
Rockbolting



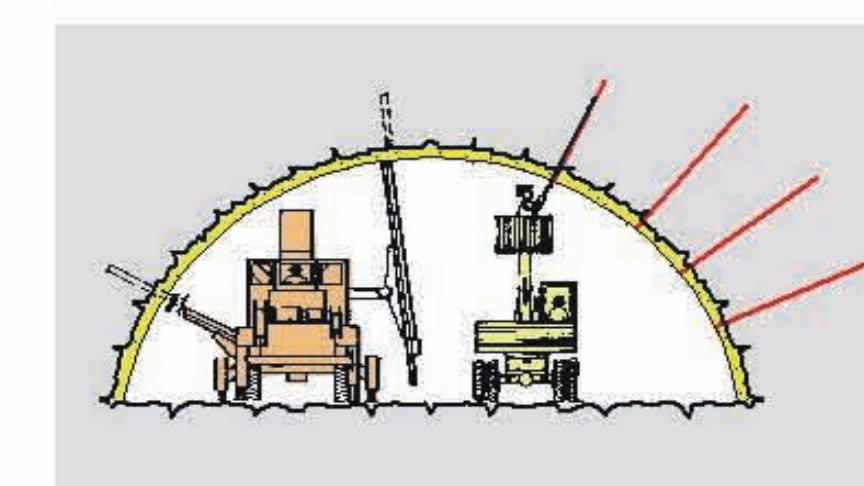
Bench Excavation



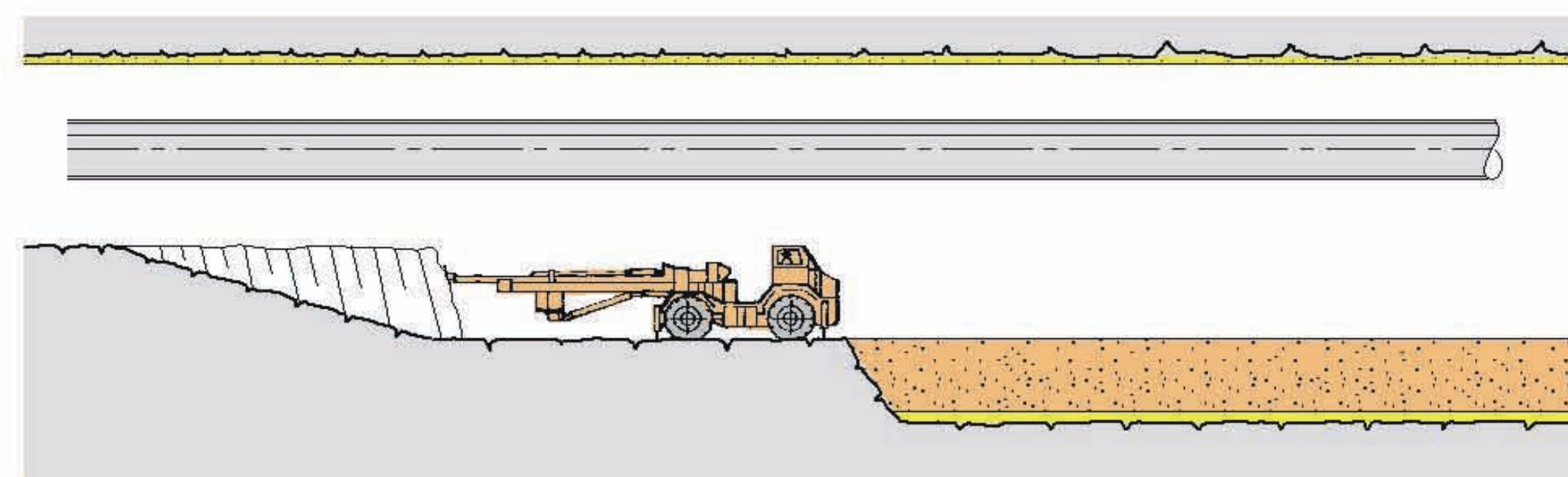
Invert Excavation
Shotcrete Arch in invert



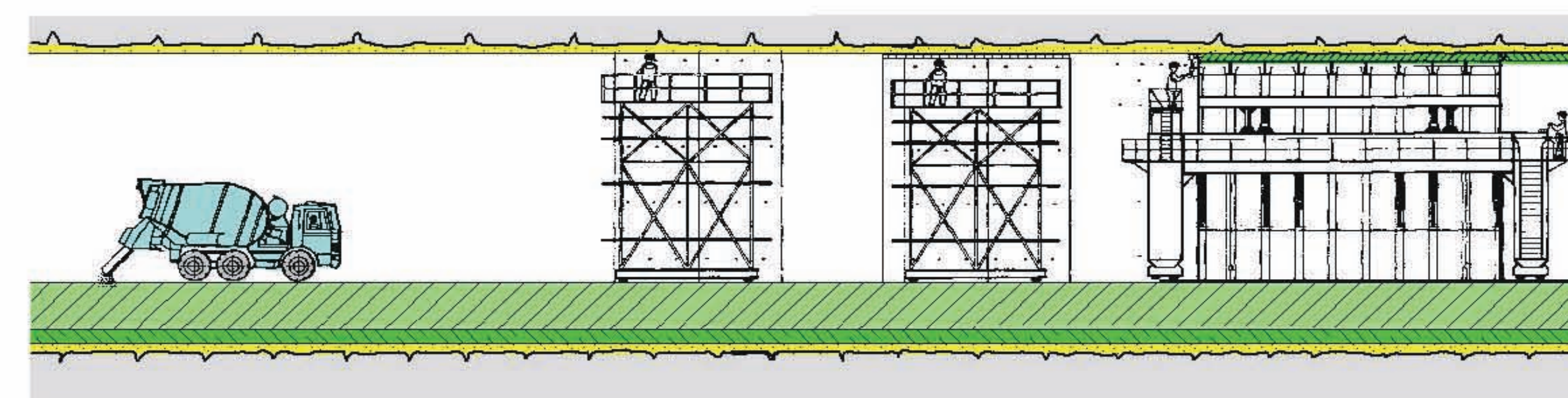
Invert Concreting



Final Lining CIP Concrete



Waterproofing



Reinforcement

Formwork

NATM Poster by ILF, Inc. Consultants